Animal Behavior: The Right Tool for the Job

A recent study has shown that wild capuchins choose a functionally appropriate tool from a set of apparently similar tools, suggesting a surprising level of understanding of the contingencies of tool use.

Sarah F. Brosnan

Tool use has long been considered a hallmark of cognitively advanced species. Successfully using a tool requires not only understanding the relationship between the tool and the goal, but the ability to locate a tool which is appropriate for the task. Existing data suggest that several species have the capacity to choose a tool on the basis of functional characteristics necessary for the task. But these data are typically correlational and rely on immediately obvious characteristics of the tools: the animals' actions could be due either to understanding the necessary parameters of the tool, or to practice with existing tools. In this issue of *Current Biology*, Visalberghi *et al.* [1] report strong evidence that capuchin monkeys take the functional characteristics of a tool into account when choosing a hammer stone to crack a nut (Figure 1), even when the tools are visually identical. Ironically, these monkeys have previously shown only limited abilities to perform this task in experimental settings [2]. The new observations indicate that these monkeys may be far more discerning than previously assumed, and that a true understanding of the contingencies of a tool use task may be widely present among animals.

Previous tool-use studies in non-human primates have indicated sensitivity to the parameters of the task. For instance, chimpanzees choose nut-cracking tools on the basis of the hardness of the nut to crack, and transport tools over long distances to obtain the appropriate one [3]. Apes also use tools in a wide variety of other situations [4], plan ahead [5,6], and make tools by modifying objects available in their environment [7]. Moreover, many of these tool use tasks appear to be passed on socially, for instance from mother to offspring [8]. Among monkeys, several species use tools during foraging behaviors [9,10], and capuchins select tools of the appropriate weight when nut cracking [11].

Of course, primates are not the only taxa that use tools, nor are they the only animals which are selective in their choice of tools [12–15]. The non-primate champions of tool use and manufacture are New Caledonian crows, a corvid species which shows selectivity based on tool length [16] and diameter [17], and can select the proper tool even when it has been 'disguised' by bundling with another tool [17]. Moreover, these crows manufacture and modify tools [18,19]. Thus, it is clear that a wide variety of species can discriminate appropriate tools, even in novel situations.

In none of these cases, however, is there clear evidence that the animals fully understand the task parameters. Often data are gathered in the wild, making it unclear whether they truly understand the parameters of the task, or have simply learned through trial-and-error which tools are the most effective. This latter possibility does not require any deeper understanding of the functional characteristics of the tools. Even experimental tasks have relied upon functional characteristics which were correlated with an immediately obvious, but potentially irrelevant, characteristic, such as size being correlated with weight. Thus, individuals could solve these tasks by matching the current tool to ones used previously, without a true understanding of the relationship between the task and the tool characteristics (for instance, that weight is the relevant feature).

What is different about the new study by Visalberghi *et al.* [1] — in which the weight of the stone was the critical feature, with size as the potentially misleading characteristic — is that the capuchin monkeys search for the critical functional feature (weight) even when other potential cues (size) are identical, or, even more impressively, when they contradict the critical feature. In these cases, the monkeys resort to techniques which can provide the appropriate weight information irrespective of the object's size. This requires more than matching based upon previous experiences, and implies an understanding that not all tools which look appropriate necessarily are so.

In this study [1], capuchins were able to choose the appropriate tool from a range of options. Choices were made before any attempts to crack the nut in question, and among novel hammer stones, ruling out trial-and-error learning. Unlike many other experimental tool use studies, this one involved a group of wild capuchins who were already engaged in nut cracking, using stones that were available naturally [20]. All natural stones were removed and replaced with experimental tools. In the first series of studies, capuchins again demonstrated that they would choose the more appropriate of two tools when visual differences sufficed to discriminate between them. First, the monkeys were presented with choices between two stones made from minerals they would encounter in their normal environment, sandstone and siltstone. The monkeys reliably chose the functional siltstone, which is less likely to splinter when used as a hammer. In the second test, capuchins reliably chose the heavier of two stones of the same material (quartzite) but different size and weight (heavier stones are required to crack the nut).

The more difficult choices were those in which experimenters created artificial rocks of variable weight and size, such that size no longer predicted weight. In the first experiment, the artificial stones were identical in size but varied in weight, yet all but one capuchin continually chose the heavier of the stones, even though their initial interactions were randomly distributed between the two stones. In the second experiment, the stones presented provided visual cues that conflicted with their true properties; the smaller stone was the only one heavy enough to crack a nut. Again, all subjects chose the heavier stone, based on the weight cue rather than the more obvious size cue (Figure 1). Finally, in the third experiment, the subjects were presented with two large (one heavy, one light) and one small (light) stones. Despite the information from the

Figure 1. Tool selection by capuchin monkeys.

Mansinho, an adult male bearded capuchin, cracks open a palm nut on a sandstone anvil. In this case, he was given a choice between two artificial stones, one heavy and small and the other light and big, and correctly selected the smaller and heavier stone as his hammer. (Photo by Elisabetta Visalberghi.)

previous study — and the choice between two larger stones — all capuchins again chose correctly. Critically, in all of these studies, the subjects had to evaluate the properties of the stone by interacting with it, typically by moving it, lifting it, or tapping it, because visual cues were no longer informative. Thus, these capuchins did not simply learn through trial-and-error to identify stones of certain mineral composition or size, but appeared to understand that the most important characteristic of the hammer stone was weight, and evaluated their choices accordingly.

This paper [1] adds two interesting angles to the literature. First, this ability was demonstrated in a species which was initially believed not to regularly use tools, based on experimental studies [2]. This reiterates the importance of investigating behaviors across multiple studies, as well as the importance of providing the animals with sufficient experience and enrichment for these sorts of abilities to emerge. Second, the authors provide sound evidence that animals use more than just past experience to evaluate objects, and actually understand the critical characteristics relating to the task at hand. This implies that these monkeys, and quite possibly other species, are far more discerning than previously believed. It will be interesting to see whether future studies find this same discrimination in other tasks and among other species. Such knowledge will help to clarify the conditions which lead to the emergence of an understanding of complex tasks in animals.

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Department of Psychology & Language Research Center, Georgia State University, PO Box 5010, Atlanta, GA 30302-5010, USA.
E-mail: sbrosnan@gsu.edu

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Hedgehog Signaling: Is Smo a G Protein-Coupled Receptor?

The Hedgehog signal transducer Smoothened is structurally similar to G protein-coupled receptors. Now there is direct evidence that Smoothened relies on heterotrimeric G proteins in order to transduce the Hedgehog signal.

Melanie Philipp and Marc G. Caron

The Hedgehog (Hh) signaling pathway is one of the most important and evolutionarily conserved pathways associated with embryonic development, and cancer and is involved in the formation and homeostasis of a multitude of tissues and organ systems [1]. Smoothened (Smo) is the transducing molecule of the extracellular signal Hh following its interaction with the receptor Patched. Topographically, Smo resembles a seven transmembrane domain protein with a high degree of similarity to the family of G protein-coupled receptors.

Seven transmembrane receptors are called G protein-coupled receptors